Indirect-Drive Experiments Utilizing Spherical Hohlraums with Tetrahedral Illumination on Omega

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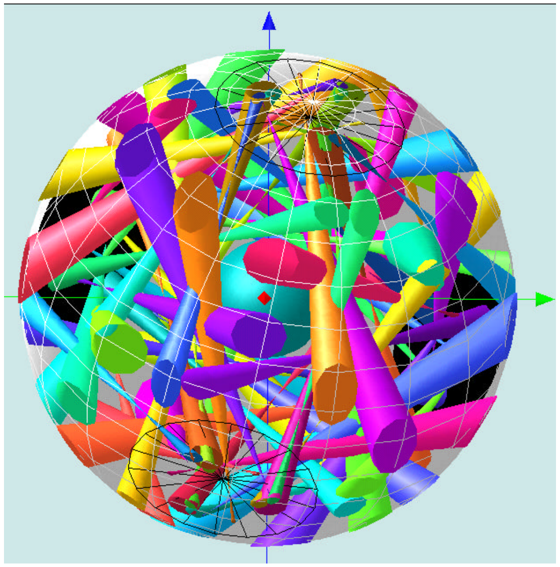

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These experiments were a proof-of-principle series for spherical hohlraums on Omega

- Investigated an alternate geometry for NIF hohlraums
- Demonstrated the use of all 60 beams in an Omega hohlraum
  - Demonstrated the ability to shoot tetrahedral hohlraums on Omega
  - Determined what problems are associated with using this geometry
  - Motivated the development of three-dimensional visualization, design, and analysis tools

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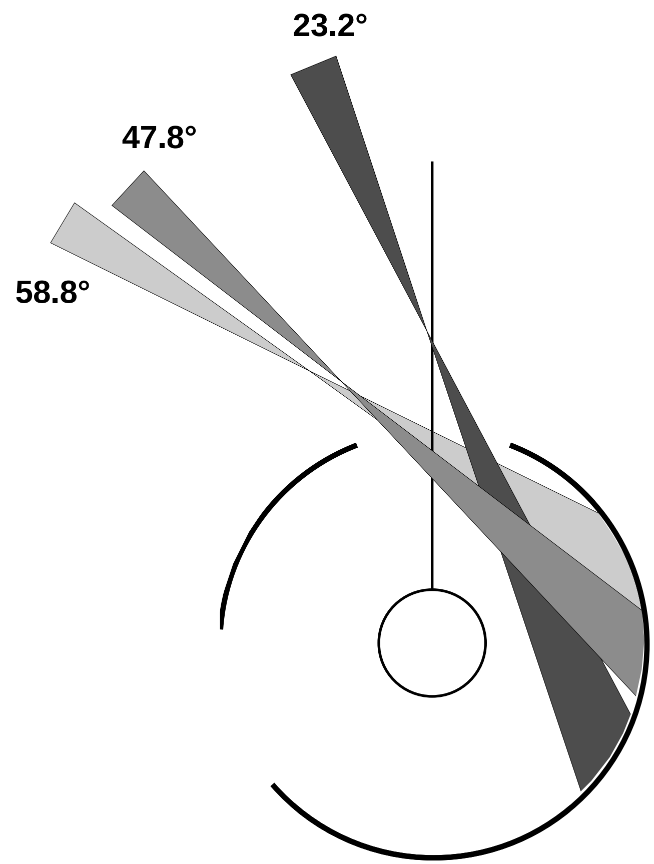
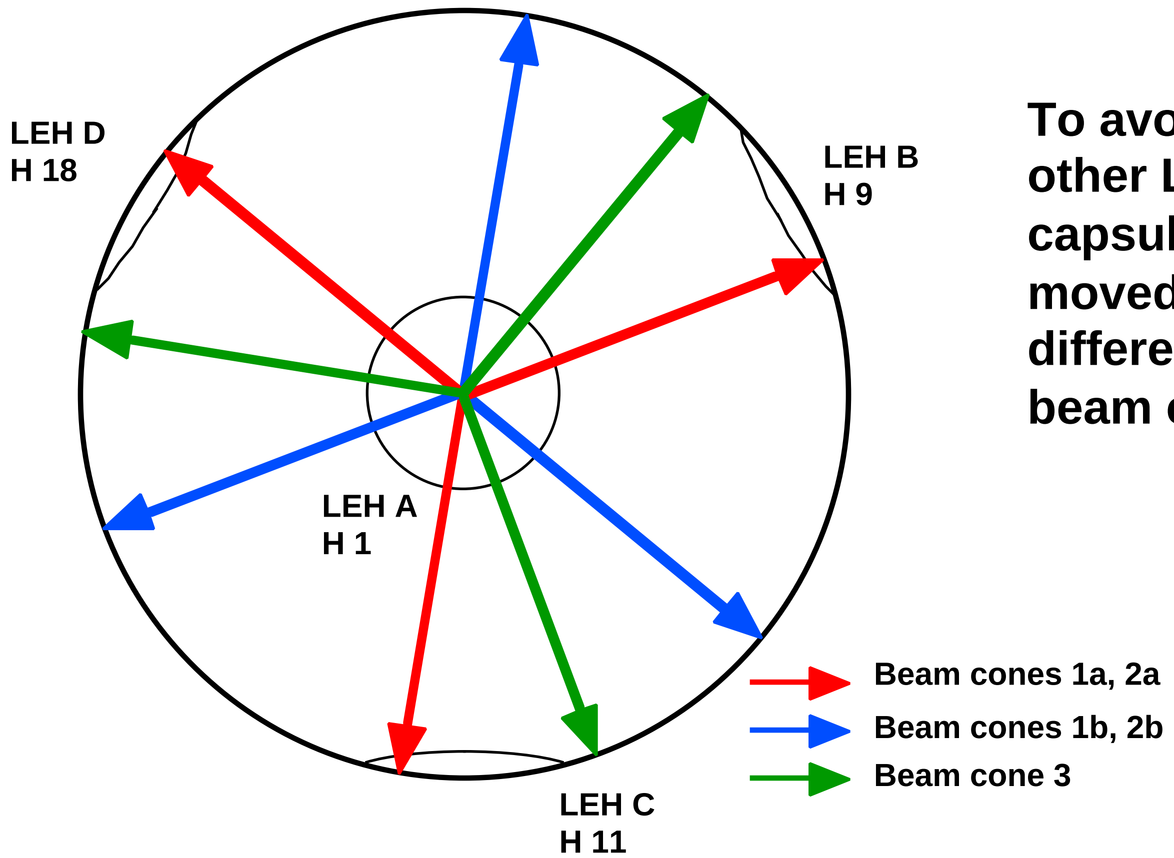
Three beam cones enter each laser entrance hole

Cone	Angle	Beams
1	23.2°	6
2	47.8°	6
3	58.8°	3



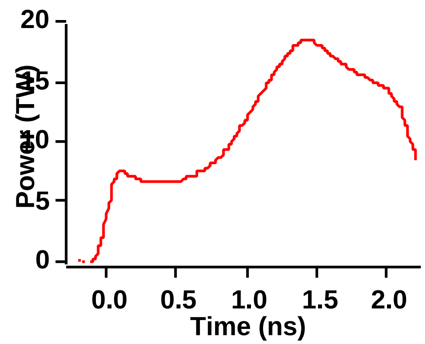
A major design issue for these experiments is laser pointing



To avoid passing through other LEHs and avoid the capsule, the beam pointing is moved off center, and differently for each three-beam cone.

Laser performance was good

- Each beam had >99% chance of working (For 59 or 60 beams, this led to 5 of 13 shots not having all beams)
- PS 22 looked very good



- Pointing accuracy was about ~30 µm RMS, with a few beams >50 µm out. (Outliers were fixed prior to shots)
- Beam energy balance was about ~5% RMS when all beams fired

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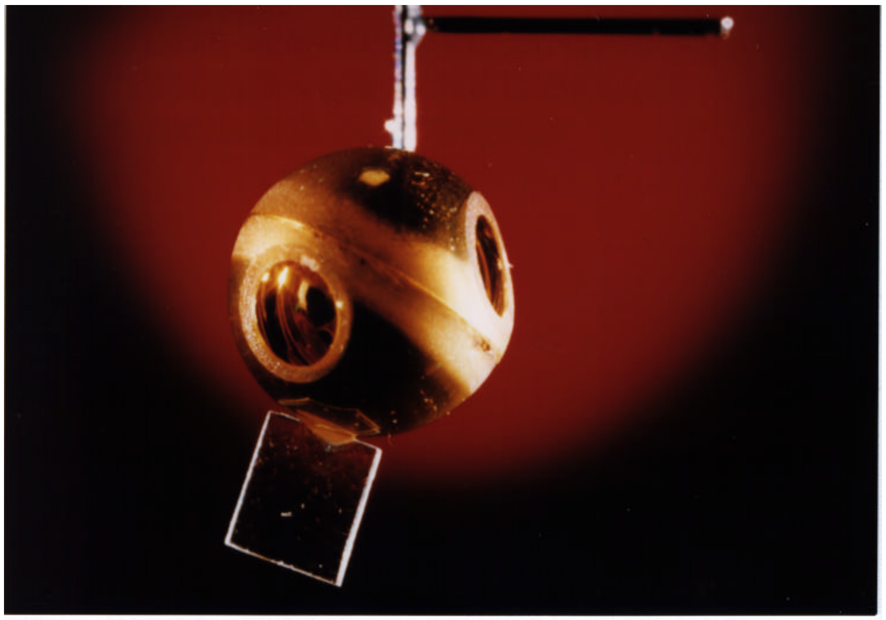
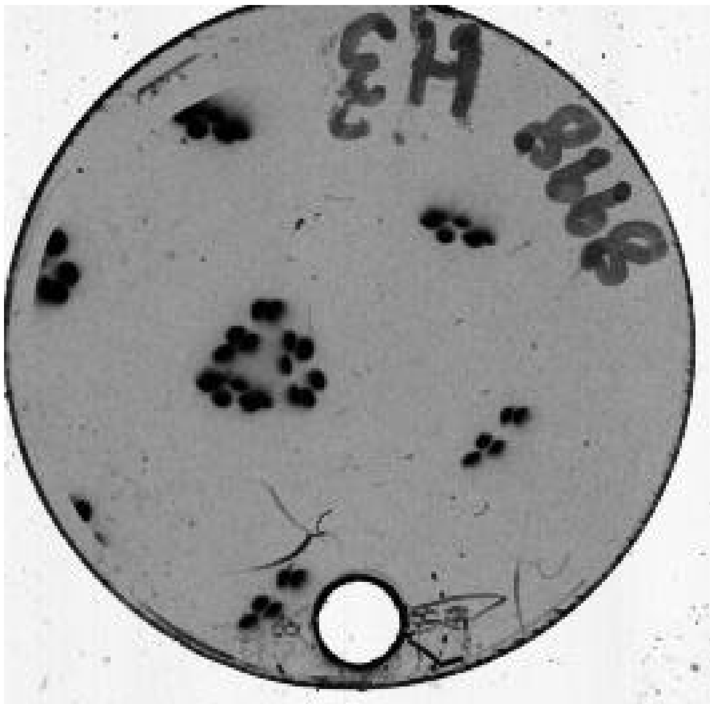
Targets were produced from thin-wall hemispheres

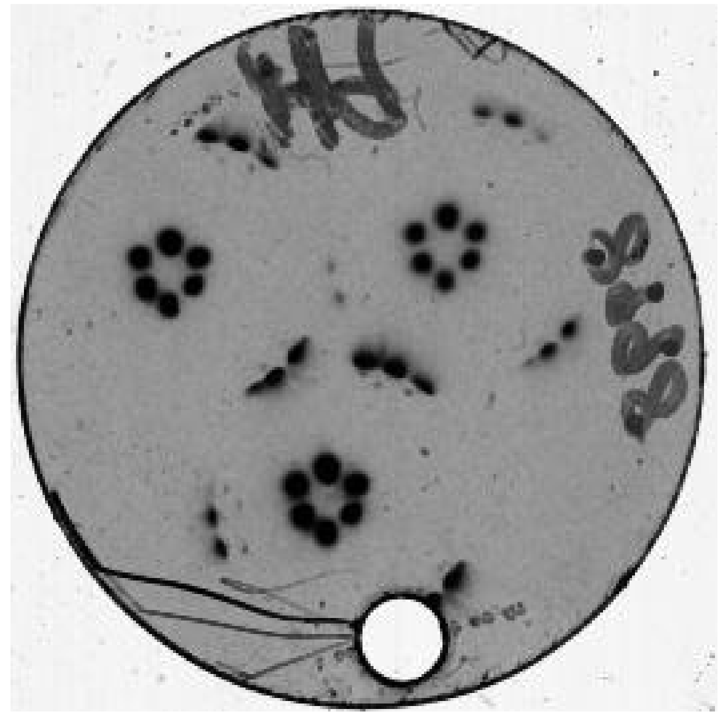


Drive target

Reemit target

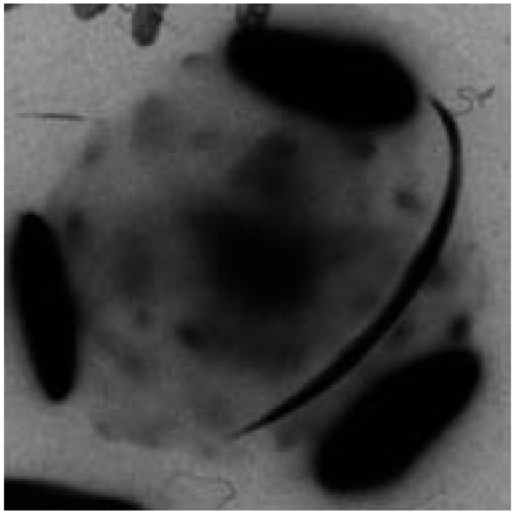
Laser pointing was verified by shooting 24 beams at a time onto 3/32” diameter pointing spheres



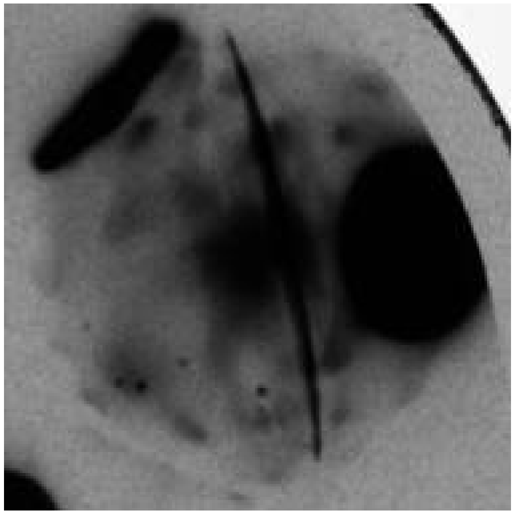


3/32” = 2381 µm

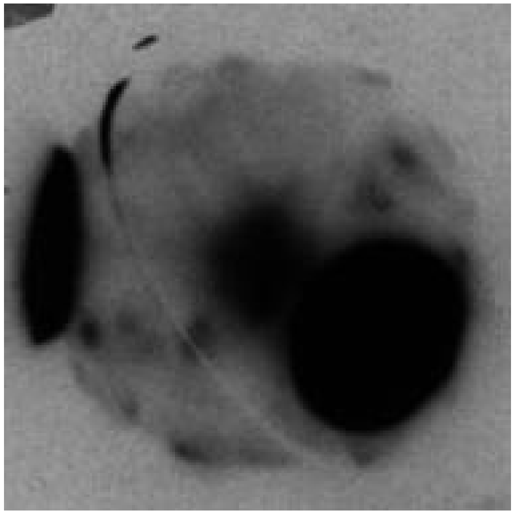
Drive shots demonstrated stagnation at the center of the sphere



H12



P12



H8

Shot 9013
Scale 1 Drive
31.5 kJ in 59 beams
(one beam off, one beam low)

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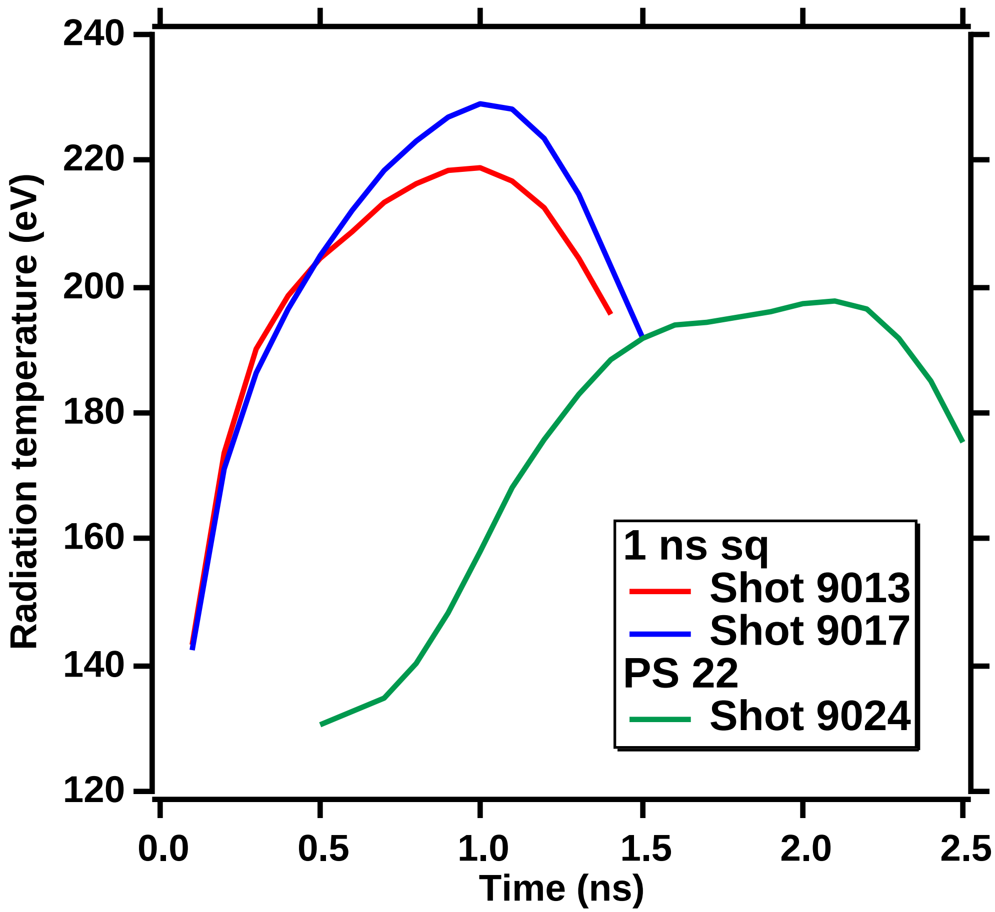
Preliminary drive temperatures have been determined for three drive shots

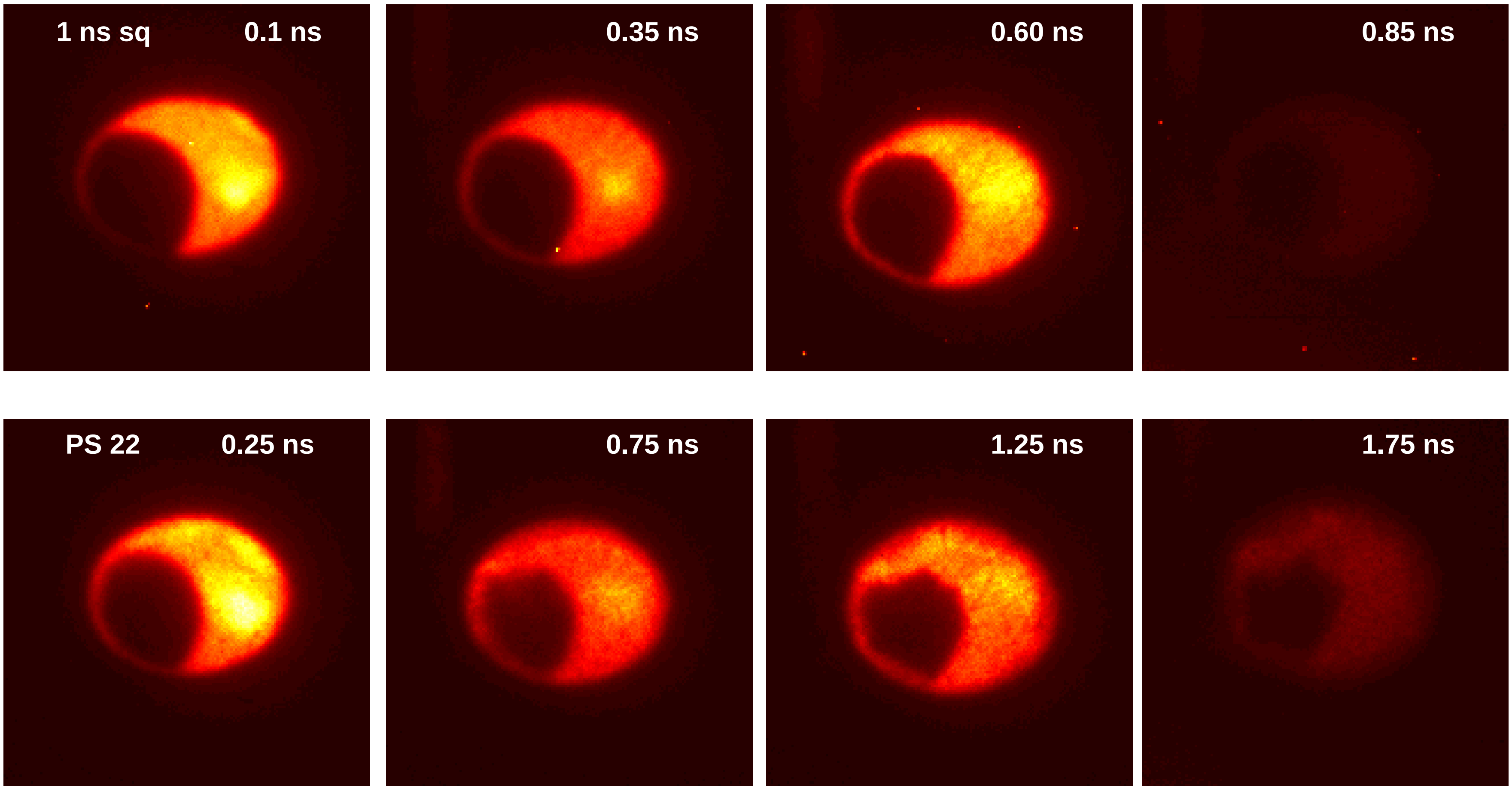


1 ns square
9013: 31.5 kJ 221 eV
9017: 30.5 kJ 231 eV

PS 22
9024: 24.6 kJ 198 eV

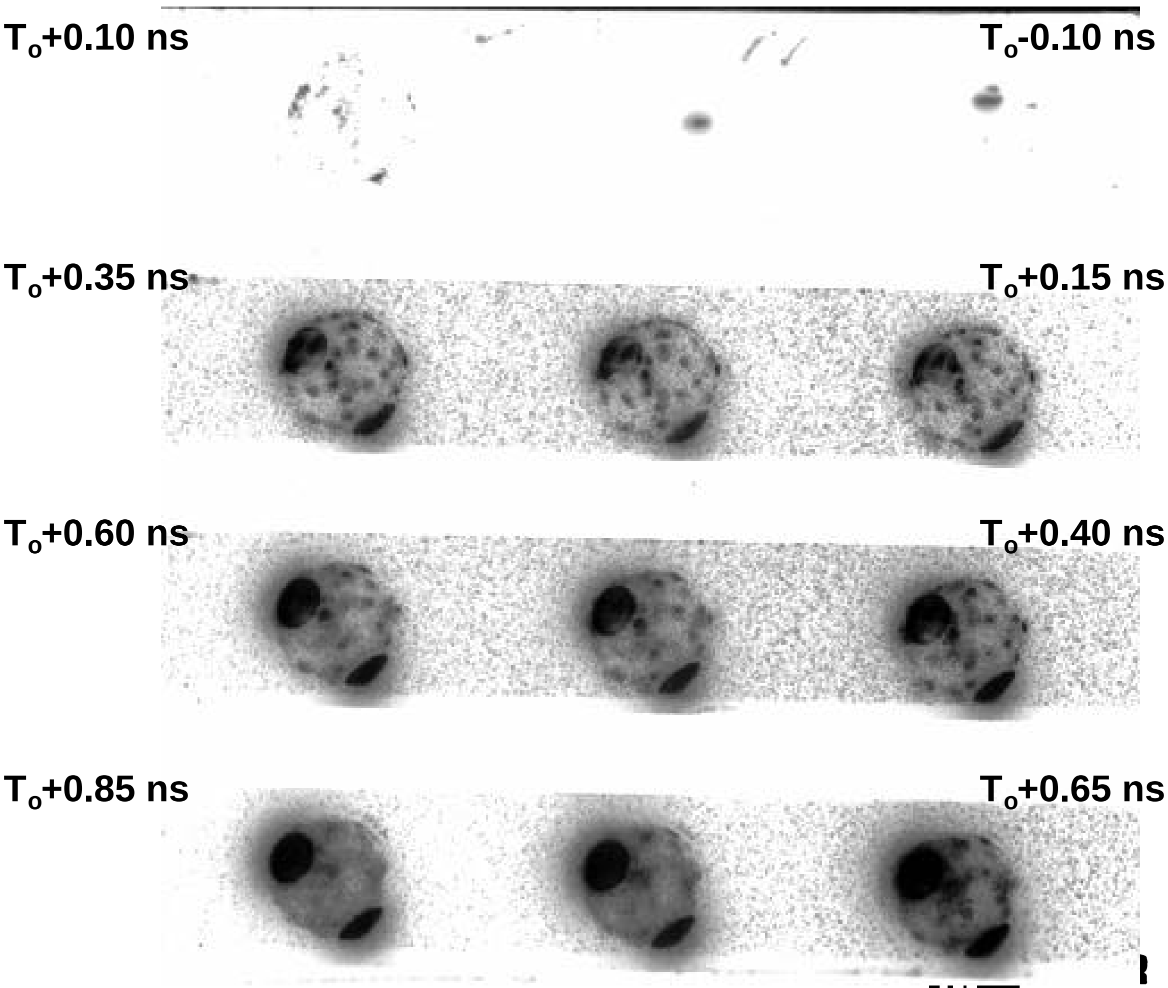
Scale 1.2, 1 ns square (not shown)
9052: 32.0 kJ 209 eV

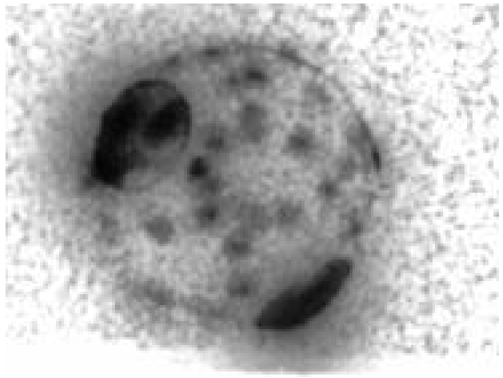
Hole closure was seen with PS22, but not significantly with 1 ns sq



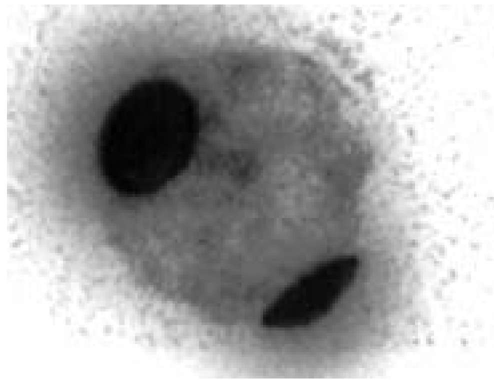
Images appear to be slightly later than requested

Laser spots disappeared at late time and were more prominent in drive targets than in implosion targets





0.35 ns



0.85 ns

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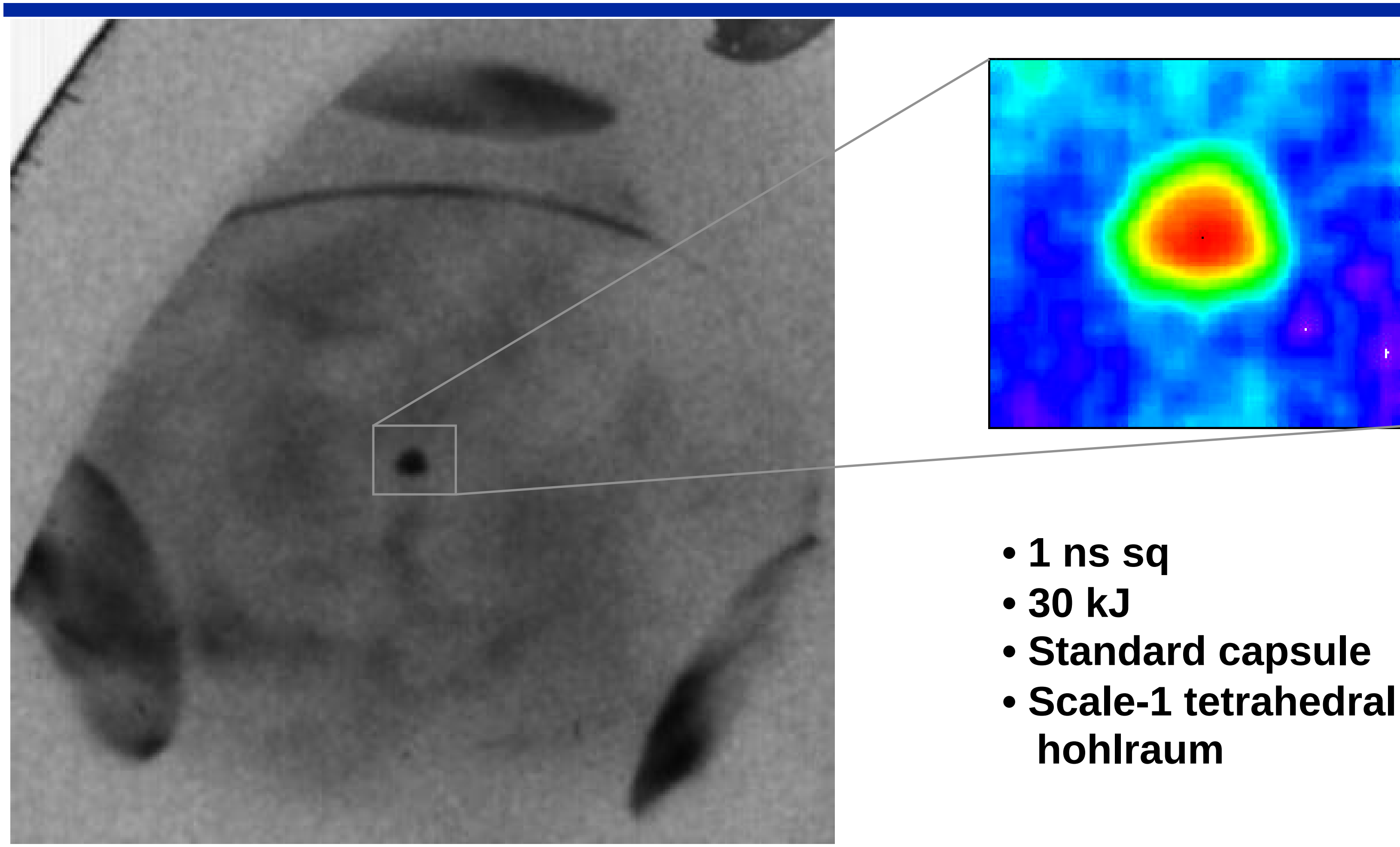
Spherical hohlraums with tetrahedral illumination have yielded triangular implosion images

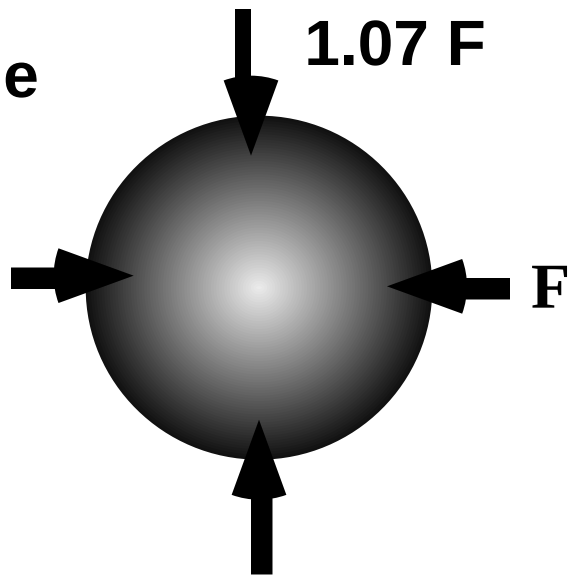


- 1 ns sq
- 30 kJ
- Standard capsule
- Scale-1 tetrahedral hohlraum

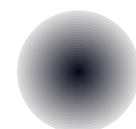
The shape of the imploded core amplifies the flux asymmetry on the capsule

$$\frac{\Delta r}{r_{final}} \quad \frac{r_0}{r_{final}} \frac{\Delta v}{v} = C_r \frac{\Delta v}{v} \quad ; \quad v_{implosion} \quad T_r^{1.5}$$

consider the example of a 7% flux asymmetry



for $C_r \sim 10$



compressed core

7% Flux $\longrightarrow$ 1.75% T_R $\longrightarrow$ 2.5 % velocity $\longrightarrow$ 2:1 distortion

Detailed comparison of experiment is made with radiation hydrodynamic modeling

experiment

detailed image and other implosion data

eg. 2D intensity contours, spectral content, temporal history

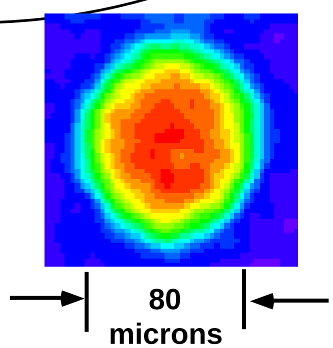
theory

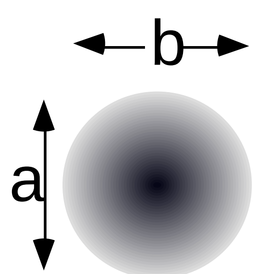
2D modeling prediction

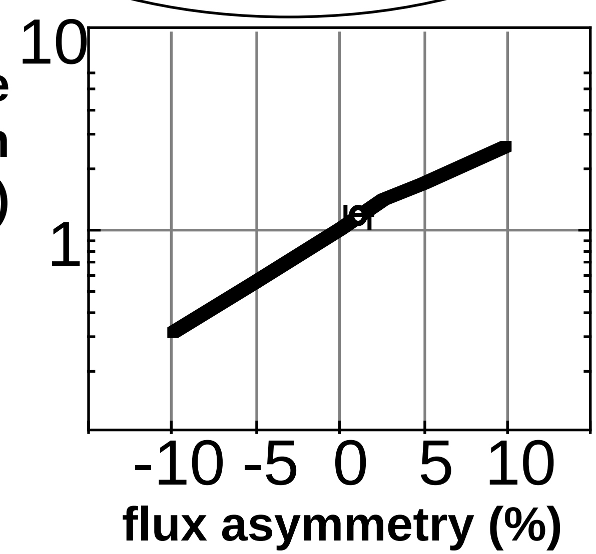
of image asymmetry for given flux symmetry

a/b~1.05

convergence ratio ~ 7

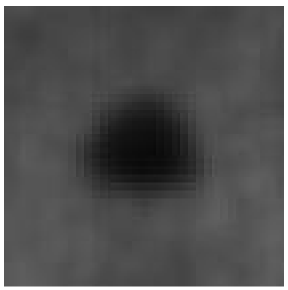
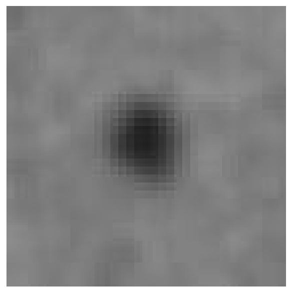
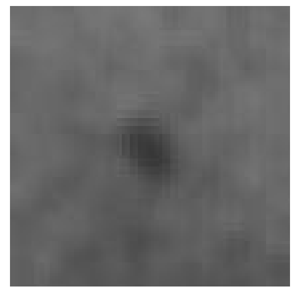
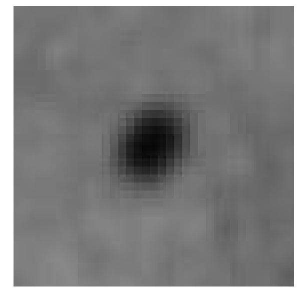
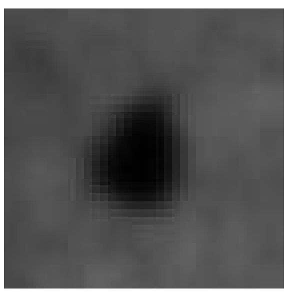
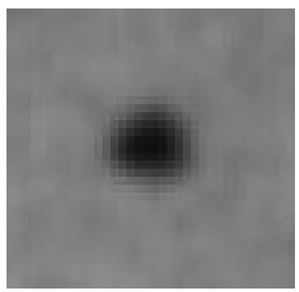
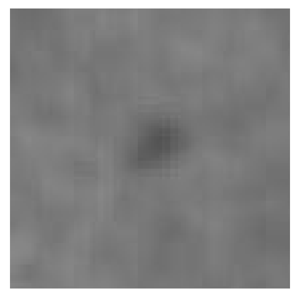
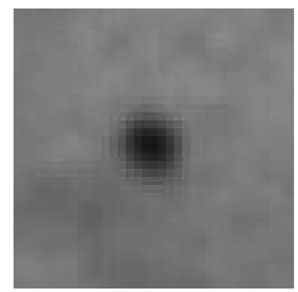




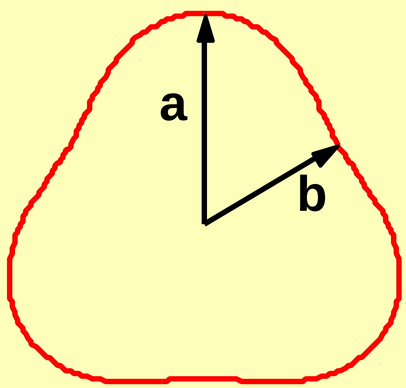


7 % flux asymmetry gives a 2:1 image distortion

Imploded core images ranged from triangular to nearly round

1 ns sq Scale 1 Std. Cap.	1 ns sq Scale 1.2 Std. Cap.	PS 22 Scale 1 Std. Cap.	PS 22 Scale 1 Sym.Cap.
 9018	 9050	 9029	 9036
 9021	 9051	 9031	 9038

The symmetry of implosions in tetrahedral hohlraums can be described in a manner similar to that in cylindrical hohlraums



Define an m=3 distortion as $d_3 = a/b$

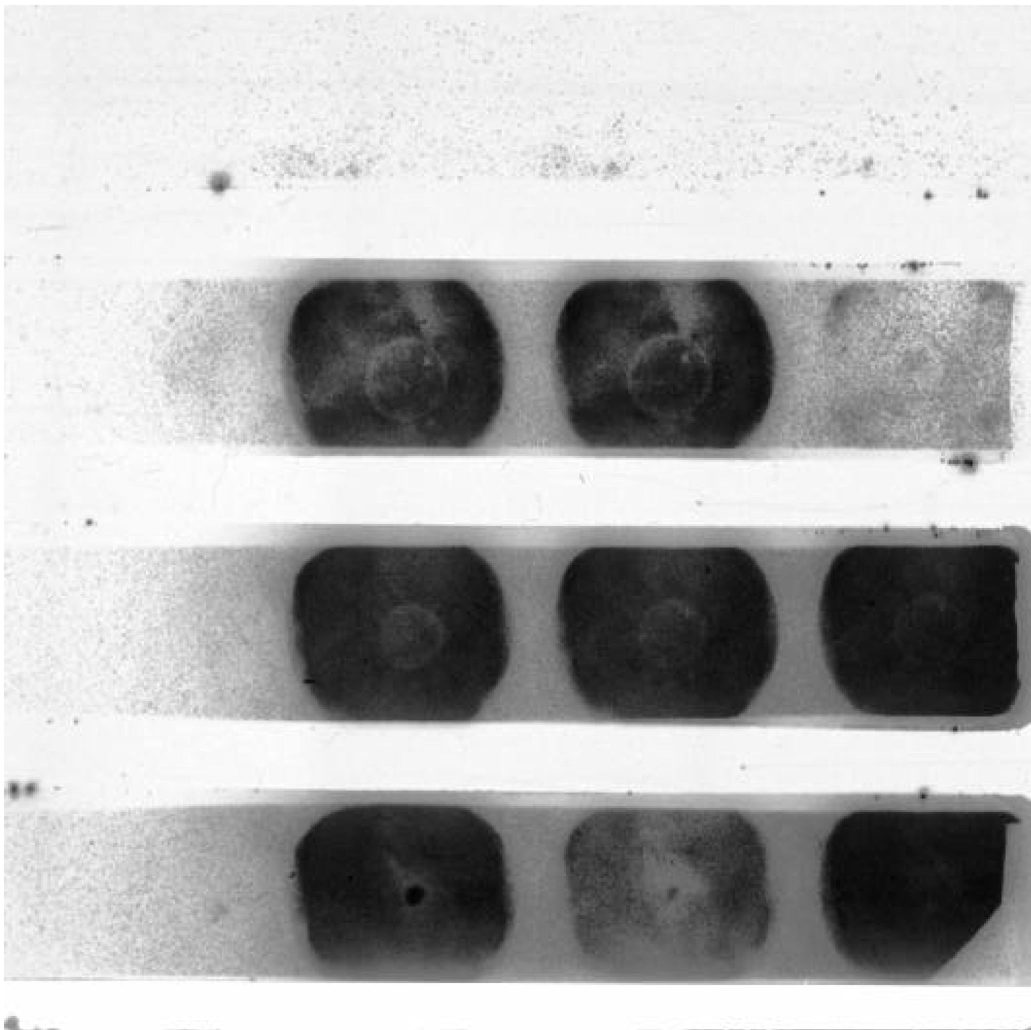
Fourier analysis of time-integrated pinhole camera data gives:

1 ns sq, scale 1:	1.16 ± 0.03
PS 22:	1.11 ± 0.06
PS 22, symcap:	1.02 ± 0.01
1 ns sq, scale 1.2:	1.13 ± 0.02

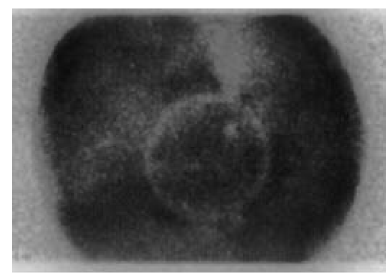
Views through an LEH and through the wall opposite an LEH are in good agreement

Round symcap data suggests that early time drive is more symmetric than at later time

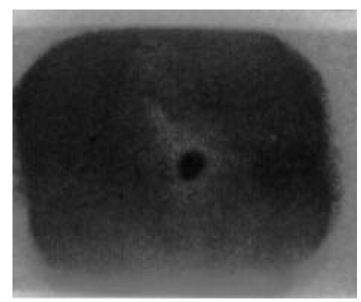
A image backlit by the hohlraum wall is obtained just prior to implosion time



Camera badly misaligned, images are off by one in up-down and left-right directions



BT-0.55 ns



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Initial conclusions from the first set of tetrahedral hohlraum experiments

- The use of all of Omega's 60 beams has produced the highest temperature hohlraums on Omega to date
- Drive asymmetry inferred from simple models of imploded core distortions indicates flux asymmetries ~2%, but the symmetry is not simple and will require 3-D modeling to understand
- Plasma blowoff may be an issue affecting symmetry
- Symcaps suggest better symmetry at early time

Future work will investigate time-dependent symmetry

- Obtain time resolved data (reemit, symcap and foam ball) in the tetrahedral hohlraum

Based on this, we may include experiments to:

- Try to improve symmetry:
  - CH lining to reduce plasma blowoff
  - Using internal shields
  - Reduce or eliminate some beam cones
- Understand tetrahedrals and show symmetry tuning
  - Larger case to capsule ratio
  - Use two different size LEHs
- Pursue Hexahedral hohlraums

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